

# Cultivar Selection Trials of Navel Orange in Arizona for 2003-04<sup>1</sup>

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## Abstract

*Three orange cultivar trials have been established in Arizona, one at the Yuma Mesa Agricultural Center, Yuma, AZ and one at the Citrus Agriculture Center, Waddell, AZ. For the navel orange trial in Yuma, 'Fisher' navel continues to have the greatest yield, but is unacceptably granulated. For the Waddell trial, the third year data has been collected, and suggests that 'Fisher', 'Chislett' and 'Lane Late' are outperforming the other cultivars tested to date.*

## Introduction

There is no disputing the importance of orange cultivars to desert citrus production. Oranges have been grown in Arizona since citrus was introduced into the state by the Spanish missionaries in the 1700's. Historically, the most commonly planted orange cultivar in Arizona was the 'Valencia'. Recently, navel oranges have become more important to the Arizona industry than 'Valencia' and other round oranges, because juicing fresh oranges in the household is becoming less common, and the American consumer prefers the convenience of eating fresh oranges. Consequently, prices received by the grower for navel oranges are consistently higher than those for 'Valencia' oranges.

Whether navel, 'Valencia' or other cultivar, a successful orange for Arizona must be adaptable to the harsh climate, (where average high temperatures are often greater than 40°C), must be vigorous and must produce high yields of good quality fruit of marketable size.

From the late 1980's, to the early 1990's, Arizona orange growers have received their information about new navel through word of mouth or from nursery sources, since there were no trials planted in the state. With this in mind, we have planted two new navel orange cultivar selection trials in the 1990's, one located at the Yuma Mesa Agricultural Center, and one located at the Citrus Agriculture Center in Waddell, AZ, just west of Phoenix.

## Materials and Methods

1995 Yuma Navel Orange Trial. This trial was established in March 1995 in Block 18 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. This trial contains the following navel orange selections on 'Carrizo' rootstock:

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- ‘Washington’ – the ‘Bahia’ navel imported from Brazil. Produces round, slightly oval fruit with segments that separate easily. Excellent flavor. Tends to granulate if planted on a vigorous rootstock, or harvested late. The Arizona industry standard.
- ‘Lane Late’ – Discovered in the 1950’s in Australia. Fruit is round, with a small navel. Matures up to four to six weeks later than ‘Washington’. Susceptible to fruit drop. Fruit has typical low acid levels.
- ‘Atwood’ - An early maturing navel selection from California. Discovered in 1935, as a limb sport on a ‘Washington’ navel tree. Stores well on the tree.
- ‘Fisher’ – Another early maturing navel selection from California. Rind coloration lags behind legal maturity. Reportedly a heavy producer.
- ‘Tule Gold’ - Another early maturing navel selection from California. Reported in some publications to be “early ripening and heavy bearing”, but other sources report poor fruit quality.

Trees are planted on a 10-m x 10-m spacing. Twelve trees of each of five scions are planted, for a total of 60 trees. Yields are expressed as lbs. fruit per tree. Yield data was collected from February 5 through 12, 2004. Trees are strip-picked for the harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. For 2003-04, the entire harvest from each tree was passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis. Ten fruit were harvested as a sample from each tree for juice quality analysis. Granulation values are determined by visual inspection of fruit cut longitudinally, and a fruit considered granulated is one in which more than 20% of the flesh is granulated.

1999 Waddell Navel Orange Trial. This trial was established in March 1999 in Field 19 of the Citrus Agricultural Center, near Waddell, Arizona. This trial contains the following navel orange selections on ‘Carriazo’ rootstock:

- ‘Beck-Earli’ (‘Beck’) – a limb sport of ‘Washington’, discovered in Delano, CA. Smaller trees are reported to be precocious and produce early maturing fruit.
- Cara Cara – Red-fleshed selection from Venezuela. Very similar to ‘Washington’ in all other respects.
- Chislett – Australian “ultra-late” selection. Reportedly can be harvested up to 3 weeks later than ‘Lane Late’.
- Fisher - Early maturing navel selection from California. Rind coloration lags behind legal maturity.
- Fukumoto – Early maturing selection from Japan.
- Lane Late – Discovered in the 1950’s in Australia. Fruit is round, with a small navel. Matures up to four to six weeks later than ‘Washington’. Susceptible to fruit drop. Fruit has typical low acid levels.
- Powell – Another Australian “ultra-late” selection. Reportedly can be harvested up to 3 weeks later than ‘Lane Late’.
- Spring – Another late navel selection.
- Washington - the ‘Bahia’ navel imported from Brazil. Produces round, slightly oval fruit with segments that separate easily. Excellent flavor. Tends to granulate if planted on a vigorous rootstock, or harvested late. The Arizona industry standard
- Zimmerman (Thomson Improved Zimmerman) – An improved selection of the ‘Thomson’, said to be 2 weeks earlier than ‘Washington’.

Trees are planted on an 8-m x 8-m spacing. There are ten complete blocks of each of the ten scion-rootstock combinations possible. Early variety fruit was harvested on 12/15/03. This includes ‘Beck-Earli’, ‘Fisher’ and ‘Fukumoto’. All other selections were harvested on 3/10/2004. Yields are expressed as lbs. fruit per tree. Trees were strip-picked for the harvest. Harvested fruit for each tree is collected in wooden or plastic boxes and weighed. The entire harvest from each tree has been passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis. Fruit grade data is not reported, as there were no significant differences between the selections. Fruit quality data for all the selections was collected on 12/15/03. Ten fruit were harvested as a sample from each tree for juice quality analysis. Granulation values are determined by visual inspection of fruit cut longitudinally, and a fruit considered granulated is one in which more than 20% of the flesh is granulated.

All data was analyzed using SPSS 7.0 for Windows (SPSS Inc., Chicago, Illinois).

## Results and Discussion

1995 Yuma Navel Orange Trial. (See Figures 1 and 2 as well as Tables 1 and 2)

Atwood: Yields of 'Atwood' have historically been lower than the other selections tested in this trial, however 2003-04 was the first season where yields have approached those of the other selections. It will be important to see if this trend continues. Fruit size for this season is comparable to the other selections, peaking on size 56, but smaller than 'Lane Late'. Fruit grade is comparable to the other selections tested. Percent juice is higher than all the other selections, except for 'Lane Late'. Total soluble solids were the lowest of all the selections tested. Peel thickness was thin, but granulation was somewhat high. Fruit shape is average, and color was good.

Fisher: Yields of 'Fisher' have been equal to or higher than the other selections tested in this trial, and 2003-04 was no exception. Fruit size for this season is comparable to the other selections, peaking on sizes 48 and 56, but smaller than 'Lane Late'. Fruit grade is comparable to the other selections tested. Percent juice is lower than all the other selections, and granulation was unacceptably high. An earlier harvest might have avoided this problem. Total soluble solids were the highest of all the selections tested. Peel thickness was average. Fruit shape is the most round of all the selections tested. Color was lower than all the other tested selections, except for 'Lane Late' indicating that coloration may be a problem.

Lane Late: Yields of 'Lane Late' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2003-04 was no exception. Fruit size for this season was larger than the other selections, peaking on size 40. Fruit grade is comparable to the other selections tested. Percent juice is higher than all the other selections. Total soluble solids were similar to the other selections tested. Peel thickness was thin, and granulation was non-existent. Fruit shape is slightly elongated, and color was not as good as the other selections under trial. Because of its greenness and lack of granulation, this selection might be harvested later in the season.

Tule Gold: Yields of 'Tule Gold' have typically been lower than the other selections under test, although after 9 years, these trees are about 50% of the size of the other selections, thus if planting density were increased, yields per acre for this selection might equal the yields of the others. Fruit size was a little smaller than the other selections, peaking on size 56, and we noticed more thrips damage on 'Tule Gold' this year, leading to lower fruit grade. Perhaps the small size fruit were more attractive to the thrips when insect populations were high in the spring. Fruit quality was similar to the other selections tested, but granulation was somewhat high, though not as high as 'Fisher'.

Washington: Yields of 'Washington' have typically been similar to yields of the other selections tested in this trial, except for 'Fisher', and 2003-04 was no exception. Fruit size for 2003-04 was smaller than most of the other selections, peaking on size 56. Fruit grade for 'Washington' was similar to the other selections tested, as was juice percentage, total soluble solids, and peel thickness. 'Washington' fruit had lower granulation levels than any other selection, except 'Lane Late', and fruit was slightly elongated. Fruit color was good.

1999 Waddell Navel Orange Trial. (See Figures 3 and 4 as well as Table 3)

*Selections harvested on 12-15-03*

Beck-Earli: The 2003-04 yield for 'Beck-Earli' decreased in relation to the 2002-03 season yield, and fell to just over 60 lbs. per tree. We have not seen the precocity reported in other publications. Fruit size, however, was the largest of all the selections tested, which may be due to the low yield. 'Beck-Earli' peaked on size 40, but had appreciable numbers of fruit size 48 and 56. Percent juice was low, as was total soluble solids. Fruit peel was the thickest and fruit was the most oblong of all the selections tested. Fruit was not as orange as 'Fukumoto' but not as green as 'Fisher' in mid-December.

*Fisher:* Yields of 'Fisher' were the highest for any of the selections tested in this trial, at about 140 lbs. per tree. It is instructive to note that when comparing the 2 trials, 3<sup>rd</sup>-year yields of 'Fisher' at Waddell were about 3.5 times the 3<sup>rd</sup>-year yields of 'Fisher' in Yuma, and 3<sup>rd</sup> year Waddell yields were 40% higher than the highest (5<sup>th</sup>-year) yields in Yuma. For the early-maturing navels, fruit size was smaller than 'Beck-Earli', but larger than 'Fukumoto', peaking on size 56. Fruit quality measurements suggest that percent juice, pH, and total soluble solids of 'Fisher' are similar to the other selections tested. Peels of 'Fisher' were the thinnest of all the early selections tested, but this selection also had the most granulation (although not as much as in the Yuma trial). 'Fisher' also had the roundest fruit, but had the least coloration of all the early-picked selections.

*Fukumoto:* 'Fukumoto' yields were slightly higher than those of 'Beck-Earli', at about 80 lbs. per tree, but only about 60% of the yields of 'Fisher'. Fruit size was the smallest of the three selections harvested early, but still peaking on size 56. There were fewer 'Fukumoto' fruit of size 36, 40 and 48 than 'Beck-Earli' and 'Fisher' fruit in the same categories. Fruit quality measurements suggest that percent juice, pH, total soluble solids, peel thickness and fruit shape of 'Fukumoto' are similar to the other selections tested. 'Fukumoto' was the only early-harvested selection that had no granulation, but had the most coloration of all the early-picked selections.

#### *Selections harvested on 3-10-04*

*Cara Cara:* Cara Cara yields for the three years of this study have neither been exceptionally high nor low, and remain just over 90 lb. per tree for 2003-04. Fruit size of this selection was one of the smallest, along with 'Washington' and 'Zimmerman', peaking on sizes 72 and 88. This selection had the fewest fruit of sizes 36, 40 and 48 of all the selections tested. Fruit quality for 'Cara Cara' was similar to most of the other selections, except this selection had the greatest total soluble solids.

*Chislett:* For 2003-04, 'Chislett' yields, about 110 lbs. per tree, were second only to 'Lane Late' among the late-harvested orange selections. This is a marked improvement over the previous season when yields for this selection were clustered with several others at about 40 lbs. per tree. If yields continue to improve for this cultivar, it might be suitable for large-scale planting. Fruit size for 'Chislett' was the largest for all the selections harvested late, peaking on size 56. Most fruit quality parameters were similar to other selections; but 'Chislett' stands out in that it, along with 'Fisher' had the roundest fruit, rather low granulation, but also that it had a relatively low coloration. This reflects the fact that the fruit can be harvested late. For the next season, we will take late fruit quality data on this cultivar.

*Lane Late:* Yields of 'Lane Late' were the greatest of any of the late-harvested cultivars, at about 133 lbs. per tree, about 20% higher than the subsequent 'Chislett'. Fruit size peaked on size 56. Most fruit quality parameters were similar to other selections. 'Lane Late' had the thinnest peel of all the late-harvested selections, and it had a relatively low coloration. This reflects the fact that the fruit, like 'Chislett' can be harvested late.

*Powell:* Yields for 'Powell' for 2003-04 were among the lowest, but the selection rebounded in 2003-04, with yields of almost 100 lbs. per tree, placing it in the middle of the selections. Fruit size was similar to 'Lane Late' peaking on size 56. 'Powell' had the most juice of any of the navel orange selections, a rather low pH, and no granulation. This suggests that granulation may not be a problem if the fruit is harvested late.

*Spring:* 'Spring' navel orange yields, at about 90 lbs. fruit per tree, were similar to those of 'Cara Cara' and 'Powell'. Fruit size was just smaller than that of 'Powell' still peaking on size 56, but with appreciable fruit of size 72. 'Spring' fruit had somewhat low juice content, similar to 'Washington' and 'Zimmerman', and the highest pH of all the selections tested. Total soluble solids were within the range of the others, as was peel thickness, and fruit shape, and granulation was low. Fruit coloration was the highest of all the selections under test.

*Washington:* 'Washington' did not distinguish itself from the other selections, unlike 2002-03, when it had the highest yield of all the mid and late-season oranges; this year it had a yield of just over 100 lbs. per tree. Fruit size was similar to 'Spring', peaking on 56 and 72. 'Washington' had the lowest juice content of all the selections, but in the other measures of fruit quality, it was neither higher nor lower than the others.

Zimmerman: 'Zimmerman' had the lowest yield of the mid-and late-season navel selections, just over 80 lbs. per tree, about 20% less than 'Washington'. Fruit size was smaller than any of the other selections, except 'Cara Cara'. Fruit size peaked on sizes 56 and 72. Juice content was low, but otherwise its fruit quality was neither higher nor lower than the others.

## **Conclusions**

Our results have not yet conclusively demonstrated that navel orange selections other than 'Washington' can be grown successfully on the Yuma Mesa. Low yields are still a problem, except for 'Fisher', but its higher yields are offset by the tremendous granulation problem. 'Tule Gold' is of interest because of its small tree and fruit size, and may achieve suitable yields per acre if planted closer together. We have not seen the fruit quality problems for this cultivar mentioned by others, but it will be interesting to see if the fruit grade problem persists.

In Waddell, we can begin to draw some conclusions; yet several more years of data are needed to characterize navel orange performance in these trials. The performance of 'Fisher' is noteworthy, yet it is again accompanied by granulation (yet much less than in Yuma). 'Beck-Earli' is disappointing because of its low yields. 'Lane 'Late' and 'Chislett' bear watching as this experiment continues.

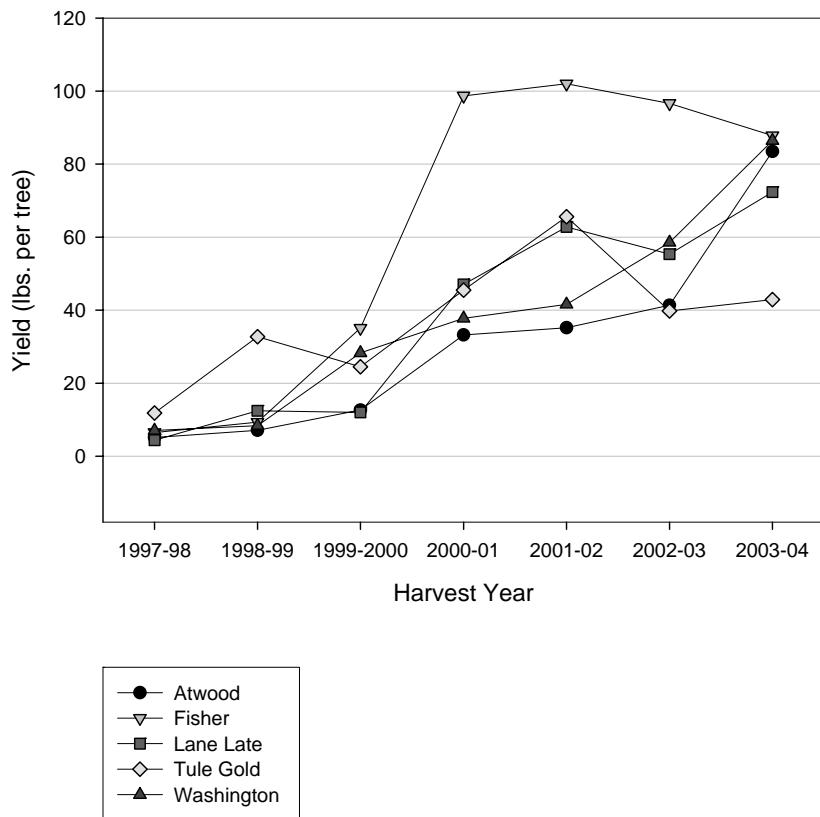


Figure 1. Yield of five navel orange cultivars budded to Carrizo rootstock.

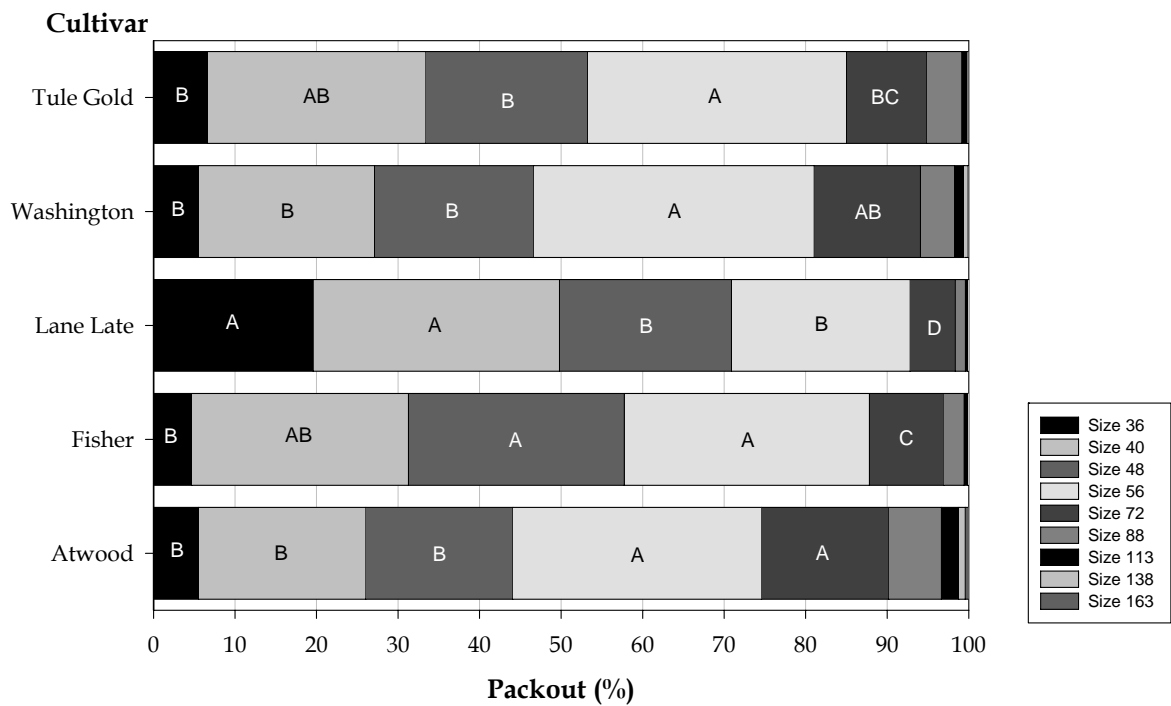


Figure 2. 2003-04 packout of five navel orange cultivars harvested on 2/12/04

Table 1. 2003-04 Fruit grade of five navel orange cultivars budded to Carrizo rootstock.

Scion	Fancy (%)	Choice (%)	Juice (%)
Lane Late	81.22 a <sup>z</sup>	12.82 b	5.98 a
Atwood	75.66 a	14.59 b	9.75 a
Fisher	77.29 a	16.23 b	6.48 a
Washington	81.74 a	12.98 b	5.28 a
Tule Gold	64.00 b	27.76 a	8.24 a

<sup>z</sup> Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 2. 2003-04 Fruit Quality of five navel orange cultivars budded to Carrizo rootstock.

Scion	Juice Content (%)	TSS (%)	Peel Thickness (mm)	Granulation <sup>y</sup> (%)	Fruit Shape <sup>x</sup>	R/G <sup>w</sup>
Lane Late	40.91 a <sup>z</sup>	11.71 ab	5.69 a	0.00 c	0.927 b	1.96 b
Atwood	36.89 b	10.98 c	5.09 b	12.50 bc	0.932 ab	2.07 a
Fisher	27.00 c	12.13 a	5.49 ab	46.67 a	0.937 a	2.05 a
Washington	35.71 b	11.87 ab	5.41 ab	9.17 bc	0.929 b	2.11 a
Tule Gold	35.70 b	11.49 bc	5.25 ab	15.00 b	0.932 ab	2.12 a

<sup>z</sup> Means separation in columns by Duncan's Multiple Range Test, 5% level.

<sup>y</sup> Granulation values are taken from 10 fruit per tree. Values represent the percentage of fruit in the entire fruit sample with more than 20% granulation.

<sup>x</sup> A value of 1.00 signifies a completely round fruit.

<sup>w</sup> Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.

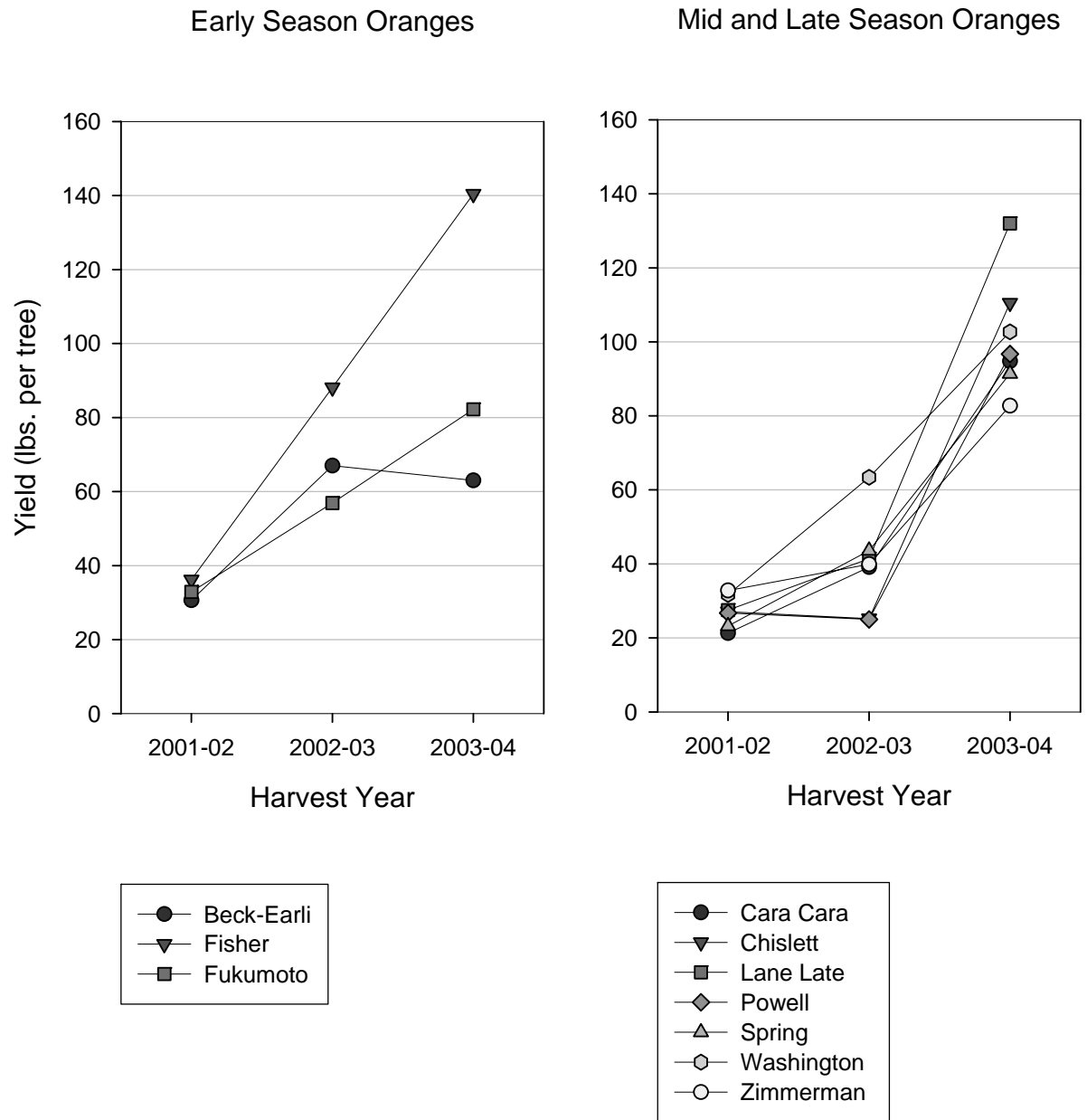


Figure 3. Yield of ten navel orange cultivars budded to Carrizo rootstock.



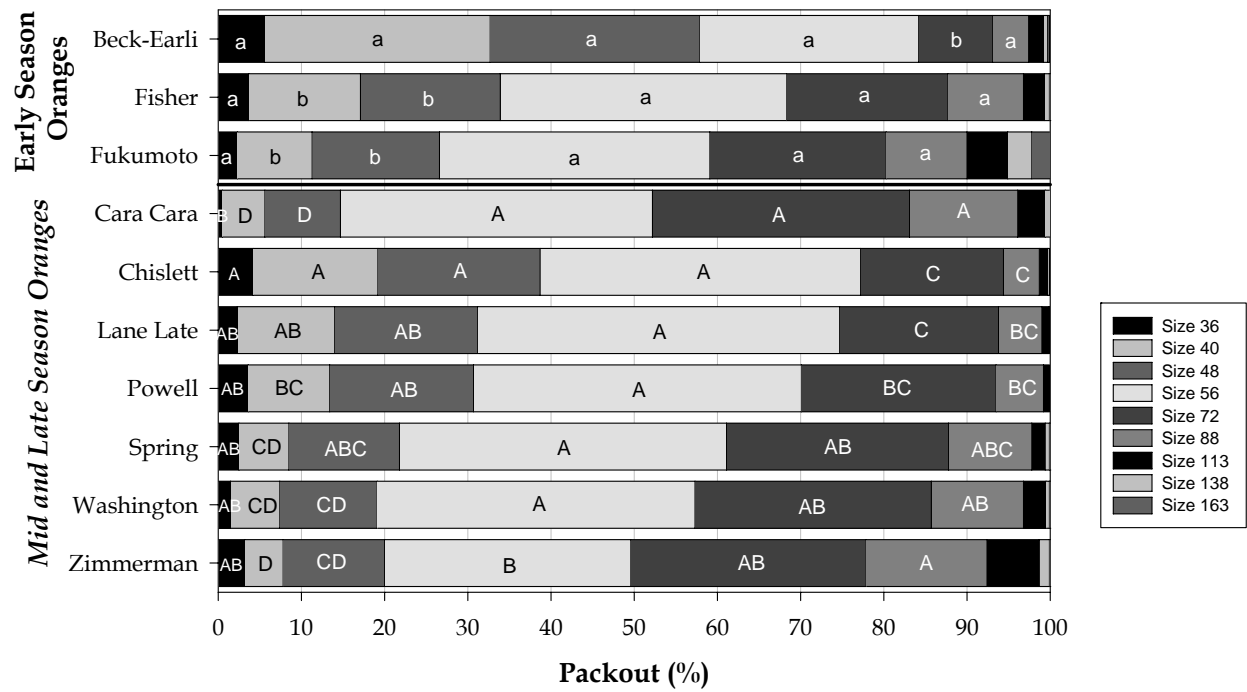


Figure 4. Packout of ten navel orange cultivars harvested on 12/12/03 and 3/10/04.

Table 3. 2003-04 Fruit Quality of ten navel orange cultivars budded to Carrizo rootstock.

Scion	Juice Content (%)	pH	TSS (%)	Peel Thickness (mm)	Granulation <sup>y</sup> (%)	Fruit Shape <sup>x</sup>	R/G <sup>w</sup>
Beck-Earli	42.04 de <sup>z</sup>	4.26 cd	12.34 d	6.52 a	0.71 ab	0.909 b	1.70 b
Fisher	45.69 abcd	4.23 de	13.47 bc	4.73 c	8.32 a	0.949 a	1.54 c
Fukumoto	44.62 bcde	4.14 e	13.13 cd	5.22 bc	0.00 b	0.946 a	1.83 a
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Cara Cara	44.12 cde	4.31 bcd	14.74 a	4.91 bc	1.11 ab	0.946 ab	2.50 b
Chislett	48.93 ab	4.41 ab	13.65 bc	5.15 bc	1.11 ab	0.949 a	2.24 d
Lane Late	48.10 abc	4.35 abc	13.26 bc	4.78 c	1.00 ab	0.946 ab	2.37 c
Powell	50.13 a	4.26 cd	13.67 bc	4.90 bc	0.00 b	0.936 ab	2.24 d
Spring	41.57 de	4.44 a	13.81 bc	5.18 bc	1.00 ab	0.929 b	2.61 a
Washington	40.28 e	4.38 ab	13.89 bc	5.41 b	4.00 ab	0.947 ab	2.48 b
Zimmerman	41.77 de	4.40 ab	14.09 ab	4.86 bc	5.00 ab	0.942 ab	2.50 b

<sup>z</sup> Means separation in columns by Duncan's Multiple Range Test, 5% level.

<sup>y</sup> Granulation values are taken from 10 fruit per tree. Values represent the percentage of fruit in the entire fruit sample with more than 20% granulation.

<sup>x</sup> A value of 1.00 signifies a completely round fruit.

<sup>w</sup> Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.